

Performance of patients with schizophrenia on the Wisconsin Card Sorting Test (WCST)

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Objective: To directly compare the performance of patients with schizophrenia and control subjects on the Wisconsin Card Sorting Test (WCST). Specifically, we sought to verify if there are significant differences on the "classical" WCST measurements (perseverative errors and number of categories), as well as on more rarely reported scores, and assess the extent to which patients with schizophrenia can improve their performance with card-by-card instructions and continuous verbal reinforcement. **Design:** Prospective cross-sectional study. **Setting:** Psychiatry department in a university-affiliated hospital. **Participants:** 30 patients with schizophrenia, diagnosed according to DSM-IV criteria, and 30 control subjects, matched to patients according to age and education. **Intervention:** The WCST was administered according to the criteria of Heaton, and a subgroup of the patients with schizophrenia was given a retest after an explanation of the WCST and verbal reinforcements. **Results:** Patients with schizophrenia succeeded on fewer categories ($t = 23.3, p < 0.001$), committed more perseverative errors ($t = 15.6, p < 0.001$), made more perseverative responses ($t = 14.6, p < 0.001$), needed more trials to succeed at the first category ($t = 9.2, p < 0.003$) and gave significantly lower conceptual level responses ($t = 14.1, p < 0.001$) than the controls. However, on retest, patients with schizophrenia committed significantly fewer perseverative errors ($t = 5.1, p < 0.001$) and showed higher conceptual level responses ($t = -3.45, p < 0.003$). **Conclusion:** Consistent with a hypothesis of frontal dysfunction in schizophrenia, patients with schizophrenia tend to show a perseverative deficit; however, some are able to partially overcome this deficit when given verbal reinforcement.

Objectifs : Cette étude vise à comparer directement la performance au Wisconsin Card Sorting Test (WCST) des patients atteints de schizophrénie à celle de sujets témoins. Plus particulièrement, nous avons voulu vérifier l'existence de différences significatives au niveau des mesures dites classiques du WCST (erreurs persévératives et nombre de catégories) ainsi qu'au niveau des mesures plus rarement rapportées, et évaluer dans quelle mesure les patients atteints de schizophrénie sont capables d'améliorer leur performance grâce à des explications à chaque carte du test et à un renforcement verbal continu. **Conception :** Étude transversale prospective. **Contexte :** Département de psychiatrie d'un hôpital universitaire. **Participants :** Trente patients atteints de schizophrénie, diagnostiqués selon les critères du

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DSM-IV, et 30 sujets témoins appariés aux patients en fonction de l'âge et du niveau d'instruction. **Intervention :** Administration du WCST selon les normes de Heaton. Un sous-groupe de patients atteints de schizophrénie a été testé une seconde fois après une explication du WCST et des renforcements verbaux. **Résultats :** Les patients atteints de schizophrénie réussissent dans moins de catégories ($t = 23,3, p < 0,001$), font plus d'erreurs persévératives ($t = 15,6, p < 0,001$), donnent davantage de réponses persévératives ($t = 14,6, p < 0,001$), doivent faire plus d'essais avant de réussir la première catégorie ($t = 9,2, p < 0,003$) et donnent un nombre de réponses conceptuelles significativement plus faible que les sujets témoins ($t = 14,1, p < 0,001$). À la répétition du test, certains patients du groupe schizophrénie ont toutefois fait significativement moins d'erreurs persévératives ($t = 5,1, p < 0,001$) et donné un nombre plus élevé de réponses conceptuelles ($t = -3,45, p < 0,003$). **Conclusion :** Conformément à l'hypothèse d'une dysfonction frontale dans la schizophrénie, les patients atteints de schizophrénie tendent à présenter un déficit de nature persévérative. Par ailleurs, certains patients atteints de schizophrénie sont capables de surmonter partiellement ce déficit à l'aide de renforcements verbaux.

Introduction

There is increasing evidence of structural and functional brain impairments in schizophrenia.^{1,2} Although these impairments are controversial, several neurological structures are at the heart of a certain consensus.³ One popular hypothesis postulates a dysfunction of the dorsolateral prefrontal cortex. The prefrontal cortex plays an important role in the processing and integration of internal and external information, in abstraction and problem solving and in the planning, execution and evaluation of behaviour. Frontal dysfunctions may lead to distortions in planning and execution and to perseverative and rigid behaviour. Several of these deficits can be measured with the Wisconsin Card Sorting Test (WCST).⁴

Several studies show that patients with schizophrenia perform poorly in the WCST categories and commit more errors on the test than normal subjects.^{5,6} Weinberger et al² have shown lower regional cerebral blood flow (RCBF) in the dorsolateral prefrontal cortex of patients with schizophrenia compared with healthy controls while performing the WCST. In the patients tested, RCBF in the dorsolateral prefrontal cortex correlated positively with cognitive performance. Other regions of the brain have also been associated with performance of the WCST, however.⁷⁻⁹

The ability to measure abstraction and cognitive flexibility is one of the WCST's advantages.^{10,11} However, authors often report only 2 scores, the number of perseverative errors and the number of categories found. A detailed analysis of WCST performance can include as many as 15 different scores related to several parameters. Aside from the number of trials, the number of successful categories and the total number of correct and incorrect responses, one can obtain other interest-

ing results, including the number of perseverative responses and the number of perseverative errors (PEs) and nonperseverative errors. It is also possible to convert these results into percentiles.

Other measurements can be particularly useful in probing the cognitive capacities of patients with schizophrenia. The total number of trials to successfully complete the first category and the number of conceptual level responses (CLR) can be linked, respectively, to the degree of initial conceptualization and the capacity for abstraction. These cognitive abilities require the proper functioning of the frontal lobe. The CLR score is the total number of consecutive correct responses in a sequence of 3 or more. This definition is based on the principle that a subject succeeding on 3 consecutive trials is considered to have at least an intuition concerning the appropriate strategy for the sorting task at hand and that the correct sequence produced is not a result of random responding. We can obtain very distinctive patterns of performance in contrasting the CLR score with other parameters. For example, a subject can score very well on the CLR without ever advancing to the second category (i.e., several sequences of 3 or more correct responses, but not a sequence of 10 correct responses). Thus, a person can possess conceptual efficiency (high CLR score) despite perseverative tendencies, as evaluated through the number of PEs. The failure to maintain set (FTMS) sheds light on conceptual instability. The FTMS score is the number of sequences of 5 correct responses or more, followed by an error, before attaining the 10 necessary for a set change. Finally, learning to learn (LTL) depicts the average tendency over successive categories for efficiency to change. The LTL score can be calculated only for subjects who have completed 3 or more categories or have completed 2 categories and attempted a third. It can be

readily seen that these additional measures can permit a deeper understanding of a deficient, "perseverative" performance.

A recent trend in WCST studies is to investigate the extent to which patients with schizophrenia can show improved performance on the task. Although many patients perform poorly on the WCST, it is unclear whether these deficits are unremediable. Several studies undertaken in the last decade have been contradictory. Goldberg and colleagues¹² found that the performance of patients with chronic schizophrenia improved on the WCST when they received explicit card-by-card instructions. However, performance dropped to baseline levels when the instructions were withdrawn. The authors concluded that patients with schizophrenia were unable to learn the WCST, suggesting unremediable deficits that were probably linked to a prefrontal dysfunction. They proposed that their failure did not result from not knowing but from not doing; in other words, the necessary information was received but was not used to change behaviour. The patients were able to learn to perform other, non-prefrontal tasks, suggesting that the performance deficit on the WCST was not due to inattention or lack of effort. These results indicate a deficit in the cognitive processes involving the use of stored information to guide behaviour and in maintaining executive control over behaviour. To integrate these notions, Gray et al¹³ proposed a model specifically designed to explain positive psychotic symptoms. The model shows a failure in acute schizophrenia to integrate stored memories of past regularities of perceptual input with ongoing motor programs. Finally, Bellack and colleagues¹⁴ report there was no evidence of transfer of training effects across problem-solving tests, despite the similarity in the cognitive demands imposed by the instruments patients were tested on.

Nevertheless, several studies¹⁵⁻²⁰ suggest that a subgroup of patients with schizophrenia can improve their performance on the WCST under certain conditions of reinforcement. Goldman and coauthors²¹ obtained better performance from patients in a cued condition than in an uncued condition. Metz and colleagues²² reported that improvements were maintained for a period of 6 weeks after instructions were given. Summerfelt et al¹⁹ found improvements after monetary reinforcements, whereas Vollema et al²⁰ found greater improvement after instructions without monetary reinforcement. Finally, Bellack et al¹⁵ and Green et al¹⁷ reported that perfor-

mance improved on the WCST when they combined monetary reinforcement with detailed instructions.

These findings indicate that some patients with schizophrenia may be able to learn the WCST, suggesting that their "frontal lobe" deficits are remediable. Moreover, when applied to rehabilitation efforts, these data highlight the importance of combining motivational and specific instructional factors for training in problem solving. In terms of neuroanatomy, the results might indicate that effective remediation requires the involvement of the prefrontal and limbic regions.¹⁷

Although the "frontal lobe" hypothesis of schizophrenia has a venerable history, we have seen that there are still gaps in our understanding of the precise nature of the deficit involved, as well as the reversibility of this deficit through reinforcement. This study addresses these issues, directly comparing a psychiatric population with controls on the WCST. More precisely, the aims were, first, to verify if there are significant differences in WCST performance on classical measurements (i.e., PEs and number of categories), as well as on other scores. Secondly, we wanted to assess the extent to which patients with schizophrenia could improve their performance if given card-by-card instructions and continuous verbal reinforcement.

Method

Subjects

The experiment included 30 patients diagnosed with schizophrenia (18 with paranoid content and 12 without paranoid ideas) and 30 healthy controls; 46 of these subjects were men, and the mean age was 42 years. The patients were referred to the project through the Department of Psychiatry at the Centre Hospitalier Robert-Giffard de Québec, and the control subjects were recruited through advertising and through personal contacts. This control group was selected to resemble the clinical group in age, sex and education level. Study participants had normal colour perception and no previous knowledge of the task.

Wisconsin Card Sorting Test

The WCST consists of 4 cards with different forms (crosses, circles, triangles or stars), of various colours (red, blue, yellow or green) and numbers of objects (1, 2, 3 or 4) on them. As the task is usually administered,

the 4 stimulus cards with the following characteristics are placed before the subject from left to right: 1 red triangle, 2 green stars, 3 yellow crosses and 4 blue circles. The subject is instructed to sort each response card under one of the stimulus cards, whichever she or he thinks is correct. After each sort, the subject is told whether the sort was right or wrong. No other instructions are given throughout the test. The instructor begins by responding "right" each time the subject matches for colour. This continues until 10 consecutive cards have been sorted by colour. The examiner then, without forewarning or comment, changes to "form" as the correct response. After 10 consecutive forms responses, the principle changes to "number" and so on. The test continues until the subject has either completed 6 categories or all 128 cards have been used.

Procedure

We followed the procedures of Heaton^{10,11} for administering and scoring the WCST. Each patient was tested in a room in the residing department. After a break of 5 or 10 minutes, patients who volunteered to continue ($n = 16$) were given detailed instructions on the 3 card-sorting principles, and then the test was readministered. Also, during the retest, card-by-card instructions (i.e., questioning errors and recalling that the sorting principle sometimes changes) and continuous verbal encouragement (i.e., gentle encouragement after a mistake and congratulatory comments after a correct response) were given. Refusal to be retested was mostly due to fatigue or lack of interest.

The control subjects were tested in a sound-proof room at Laval University and, in certain cases, at the home of the subject.

Results

The patients with schizophrenia and the control subjects did not differ on sex, age or education level (Fig. 1). A global view of the WCST results, including the effects of learning in the experimental group, is presented in Figure 2.

The performance of patients with schizophrenia was compared with controls on the following 8 variables: number of completed categories, number of trials to complete the first category, number of perseverative errors (PEs), number of nonperseverative errors, number of perseverative responses, failures to maintain set

(FTMS), number of conceptual level responses (CLR) and "learning to learn." There were significant group differences on 5 of those variables, with $p < 0.05$ (Fig. 3). Patients with schizophrenia succeeded in significantly fewer categories ($t = 23.3$, $p < 0.001$), made more perseverative errors ($t = 15.5$, $p < 0.001$) and perseverative responses ($t = 14.6$, $p < 0.001$), needed more trials to succeed the first category ($t = 9.2$, $p < 0.003$) and showed a CLR significantly lower than did the controls ($t = 14.1$, $p < 0.001$).

In these analyses of the effect of a retesting comparing the results of the first with the second test (Fig. 4), only 2 of the t -tests were significant: the number of PEs ($t = 5.1$, $p < 0.001$) and the CLR ($t = -3.5$, $p < 0.003$). For these comparisons, the same individuals were compared on the first and the second testing.

Other analyses comparing the performance of individuals with paranoid and nonparanoid-type schizophrenia showed no significant differences between these 2 groups on 5 pertinent parameters: the number of trials to succeed the first category, the number of completed categories, the number of PEs, the FTMS and the CLR.

We also compared the performance of the individuals in the retest group with those not retested, to verify that the retested patients were not in some way non-representative, but there were no differences found between those retested and not retested.

All comparisons included a correction made for the alpha (α) type 1 error that arises when a large number of t tests are done. Using the principle for correcting within a same family²³ and the equation, $1-(1-\alpha)^c$, where c is a constant equal to the number of tests, we arrived at a correction factor of 0.004.

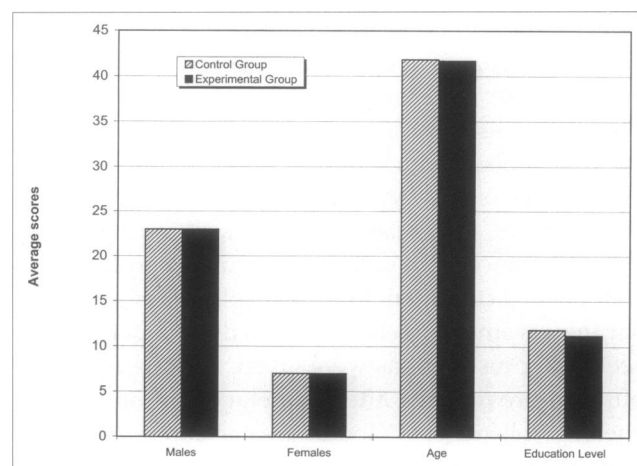


Fig. 1: Demographics of the study population.

Discussion

The main objective of this study was to verify the existence of significant differences in the pattern of performance between patients with schizophrenia and healthy subjects on the WCST on the classical measurements as well as on other scores derived from the test. The study also examined the degree to which individuals with schizophrenia are able to benefit from precise explanations and continuous verbal reinforcement.

The results indicate that individuals with schizophrenia succeed at significantly fewer categories and make more PEs than healthy controls. The patients also need more trials to complete the first category, give more perseverative responses and differ from the normal group in their CLR. These results are similar to the dysfunctions in executive functions seen after frontal-lobe damage. An attractive explanatory hypothesis for these deficits is that these patients show a diminished capacity to generate or apply cognitive inhibition. This could manifest as cognitive control deficits and frequent distraction by nonpertinent stimuli. These difficulties appear to be linked, according to certain authors,^{13,24,25} to several clinical symptoms seen in patients

with schizophrenia, such as hallucinations, delirium and incoherent thought and speech. Thus, these results verify, once again, that individuals with schizophrenia have a perseverative tendency, which could be interpreted as a cognitive inhibition deficiency and related to some of the symptoms encountered frequently with this illness.

Our data permit further investigation of the executive deficit and, indirectly, of the presumed deficit in cognitive inhibition. The FTMS and the CLR are 2 measures derived from the WCST that help to explore the mechanisms of conceptual efficiency and cognitive stability. Conceptual instability, due to deficits in inhibition, could logically lead to a high score on the FTMS measure. An analogous relationship was found in a study of the performance of patients with schizophrenia on the Stroop Test,²⁶ which suggests that these patients have difficulty in suppressing a distractor. In executing the WCST, this difficulty could be compared with the early abandon of the proper strategy and a high FTMS score. Our findings do not support this, however; the FTMS score for patients with schizophrenia is relatively low. Two explanations for this negative finding could be suggested. First, the stimuli used in

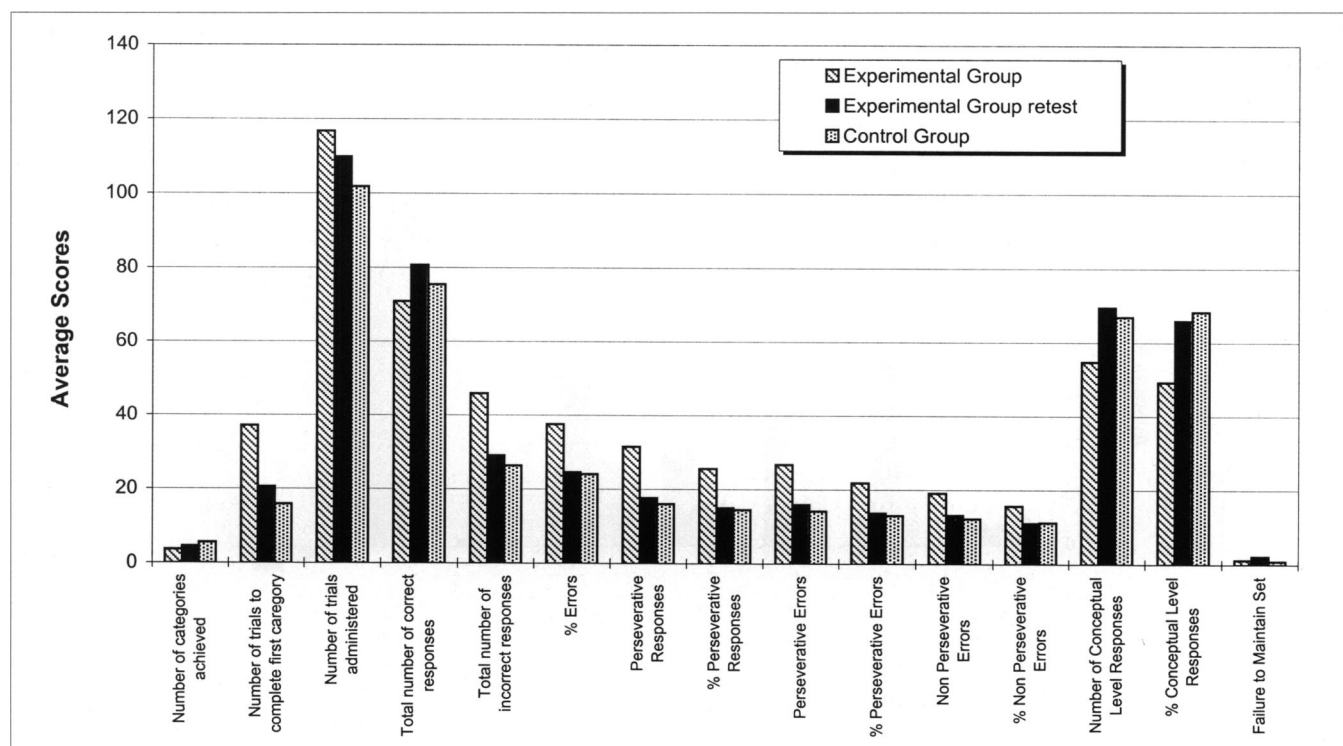


Fig. 2: Comparison of all subjects for all measurements derived from the Wisconsin Card Sorting Test, including learning effects.

these 2 tests are very different; the distracting stimuli used in the Stroop test is more overwhelming and more difficult to inhibit than those used in the WCST, which are more abstract and conceptual in nature. Perhaps patients with schizophrenia do indeed have difficulty inhibiting some distractors, but not those that are conceptual, less overwhelming or require abstracting abilities such as those needed for the WCST. Second, the negative finding could be related to the particularities of the FTMS measure itself. It is possible that the FTMS measure, demanding 5 consecutive responses, does not detect the instability of quickly abandoned concepts. It is not easy to demonstrate a "failure to maintain set" if the subject has difficulty forming sets in the first place. And the weak CLR results do effectively demonstrate that individuals with schizophrenia have difficulty forming abstract concepts. Finally, it might be noted that the patients with schizophrenia actually persevere, as shown by the high number of perseverative errors and perseverative responses. This perseverative tendency could partially compensate for a reduced capacity to maintain set: the set, once formed, could be maintained because of an increased tendency to persevere.

To what degree can one associate performance deficits in a test such as the WCST with real life situations and their inherent adaptation challenges? It is

important to question how well the processes solicited by the WCST actually represent reality. For instance, it would be premature to assume that improvement on the WCST could be associated with a reduction in the symptoms associated with schizophrenia, although it has been maintained that improvements on certain neurocognitive abilities such as verbal memory, vigilance and card sorting are correlated with the clinical prognosis.^{27,28} Deficiencies in these abilities are linked to a predisposition for schizophrenia and are at the core of the clinical prognosis.²⁷ In fact, it is reasonable to believe that verbal recall capacities are important for success in the training programs and that these encoding and executive functions are also essential for adequate day-to-day functioning in society.

It is apparent that patients able to perform well on vigilance (attention) tests and distinguish auditory signals are also more apt to adequately analyze pertinent information in the ever-changing social environment and, in the case of this study, in situations involving instructions. Therefore, knowing that these deficits limit the patient in his or her adaptive process, they become an interesting area of behavioural and pharmacological interest. Our results suggest that these patients benefit, to a certain degree, from reinforcement (verbal encouragement and explanations) without monetary compensation. They perform signifi-

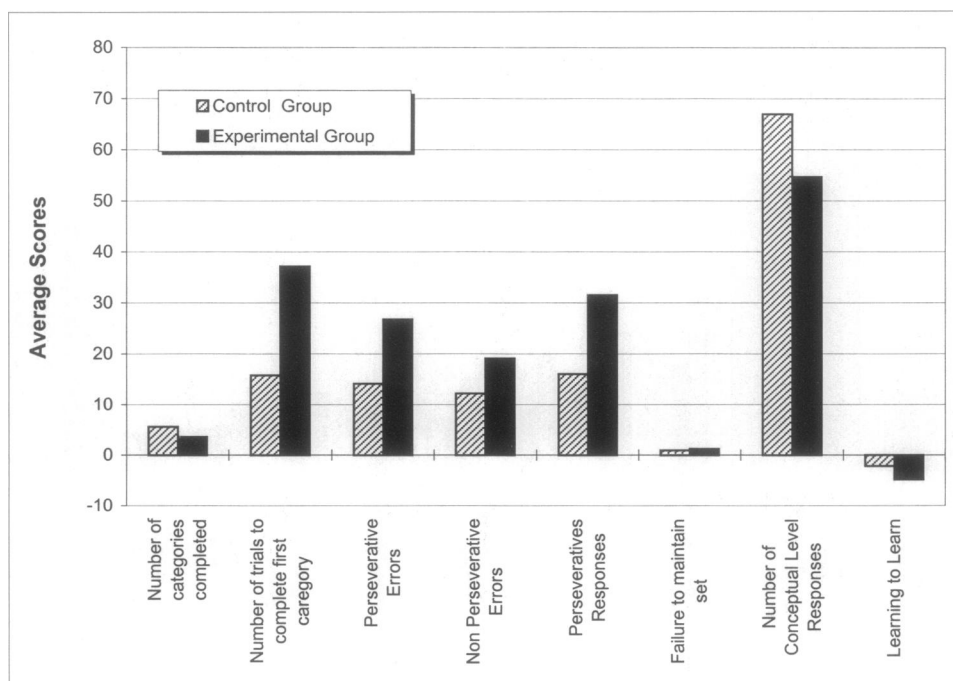


Fig. 3: Results for each parameter of the Wisconsin Card Sorting Test.

cantly better, committing fewer PEs and at a higher level of conceptualization. This outcome is encouraging, suggesting the possibility of optimizing certain cognitive abilities that are deficient in patients with schizophrenia with reinforcement methods. These methods can help the patient overcome, to a certain degree, a less efficient executive function.

There are limitations to this study. As discussed by Young and Freyslinger,²⁹ certain factors, such as the composition and size of the sample, degree of severity of the illness and variability in the protocols, were not taken fully into consideration. We found no significant difference in the WCST scores of paranoid and non-paranoid participants. This result conflicts with that of Rosse et al,³⁰ who found that patients with paranoid schizophrenia showed no neuropsychological deficit, while those with nonparanoid diagnoses did. It is interesting to note that although the number of PEs diminished on the second testing, the number of completed categories was unchanged, and there is usually a positive correlation between these parameters.³¹ It is possible that reinforcement may not have contributed to “real learning” in crucial areas of abstraction but simply to learning not to repeat the same error consecutively.

In light of our results, it is reasonable to believe that patients with schizophrenia are able to better their

performance — although not to normal levels. The fact that most patients scored higher when tested a second time suggests that a certain learning process was in effect. A case-by-case analysis might be more useful than an analysis of group means, since these comparisons tend to minimize individual differences.

Conclusion

We assessed the performance of a group of patients with schizophrenia in a test known to evaluate mental flexibility and abstract thought. These abilities belong to executive or frontal functions that allow an individual to interact with the environment and respond appropriately to change in everyday life. Our results support the contention that patients with schizophrenia have frontal lobe deficits that cause them to perseverate. However, improved performance on the test with reinforcement and card-by-card instruction suggests that cognitive training of patients with schizophrenia might improve executive functions.

Further studies are necessary before evaluating the rehabilitative prospects for this patient group. Studies using a larger and more subdivided patient base, taking into account the wide variety of clinical entities in schizophrenia, would be useful to further our

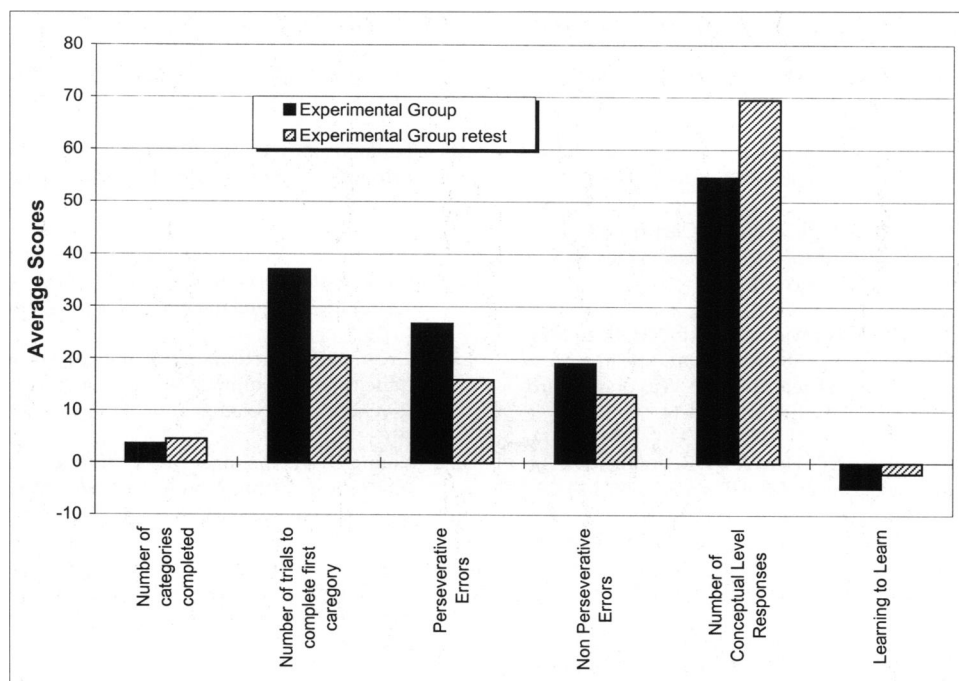


Fig. 4: Comparison of the results for the patients with schizophrenia on their first and second trials.

knowledge and develop better treatments and training programs.

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